order of the material presented has been rearranged by moving a portion of the specification, namely, page 10, line 20 – page 13, line 17, to be inserted instead at page 2, after line 15.

Prior to this amendment, Claim 1 recited "a tooth width ratio of the small rotor teeth with the small stator teeth is set to 0.35-0.45." Unfortunately, this wording is an incorrect translation of what is meant. The tooth width of the small rotor tooth and the tooth width of the small stator tooth are normally expressed by the ratio with respect to the rotor tooth pitch. Accordingly, in the claims and the specification, the wording "a tooth width ratio of the small rotor teeth with the small stator teeth is set to 0.35-0.45" is wrong and is corrected to "a ratio of the tooth width of the small rotor teeth or the tooth width of the small stator teeth with respect to the pitch of the small rotor teeth is set to 0.35-0.45."

The Examiner has objected to the drawings in paragraph 2 of the Office Action, stating that every feature must be shown in the drawings. In response, Applicant has amended the claims and submits that Fig. 3 fully illustrates what is now claimed. The ratio of either small rotor tooth width or small stator tooth width with respect to the pitch of the small rotor teeth is illustrated to be within the range specified in the claims. Note that the variances in vernier pitch are not easily distinguished in drawings such as this because of the scale of these drawings.

The Examiner has rejected Claim 1 as unpatentable under 35 USC § 103(a) in view of Applicant's admitted prior art. The Examiner has further rejected Claims 2-4 under 35 USC § 103(a) as being unpatentable over Applicant's admitted prior art in view of Harned (U.S. Pat. No. 4,873,462). Claim 5 is rejected as unpatentable under 35 USC § 103(a) over Applicant's admitted prior art in view of Satomi (U.S. Pat. No. 5,315,192). Claims 6-8 are rejected as being unpatentable under 35 USC § 103(a) over Applicant's admitted prior art in view of Harned and further in view of Satomi.

Claim 1 has been amended to recite a motor having a permeance distribution of the small stator teeth is a vernier pitch balanced by a six order harmonic wave, and a ratio of the tooth width of the small stator teeth to the pitch of the small rotor teeth is set to 0.35-0.45. Similarly, Claim 2 has been amended to recite a motor having a permeance distribution of the small stator teeth is a vernier pitch balanced by a three order harmonic wave, and a ratio of the tooth width of the small stator teeth to the pitch of the small rotor teeth is set to 0.35-0.45.

The Harned reference does not include the limitations recited above. Fig. 1 of Harned illustrates a cross sectional side view of a two-phase stepping motor. According to this Figure, it appears that a ratio of the tooth width of the small stator tooth to the pitch of the small rotor teeth is about .5. A ratio of the tooth width of the small rotor tooth to the pitch of the small rotor teeth is about .2. From this, it cannot be concluded that a range of 0.35-0.45 is the best for the ratio of the width of the stator pole teeth to the pitch of the rotor small teeth.

Further, although Harned describes adjusting the angular spacing of the rotor and the stator teeth, and changing the shape of the rotor or stator teeth, Harned does not describe changing the width of the small stator teeth with respect to the pitch of the rotor small teeth. In other words, Harned does not disclose or suggest that such a ratio as claimed is a result effective variable.

The Examiner alleges that the claimed invention would be obvious in view of the cited references because it has been held that where general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill (citing *In re Aller*).

Applicant asserts that a particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the

optimum or workable ranges of said variable might be characterized as routine skill. See MPEP § 2144.05 (citing *In re Antonie*, 195 USPQ 6 (CCPA 1977) and *In re Boesch*).

The Examiner has not cited any reference that indicates that the small stator tooth width compared to small rotor teeth pitch is a result effective variable. No cited reference indicates a manner of determining the optimum range of said variable, or even suggests that cogging torque may be further reduced, or magnetic flux density further increased, by manipulation of this variable. Thus, Applicant asserts that the cited references provide no motivation to arrive at a motor as defined in independent Claims 1 and 2.

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

The Commissioner is hereby authorized to charge any additional fees which may be due, or to credit any overpayment made, to Deposit Account No. 50-2522.

Respectfully submitted,

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AMENDMENT AND RESPONSE TO OFFICIAL ACTION DATED
Applicants: Kazuo OSHNISHI, et al.
Serial No.: 10/082,000
Examiner: Hanh N. NGUYEN
Art Unit: 2834
Atty. Dkt.: W1010.136-US-01 *[Formerly 134.140]*

Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 50-2522

CERTIFICATE OF MAILING

I hereby certify that this document is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on **18 February 2003**.

J. White
Printed Name

JWhite
Signature

ATTACHMENT REDLINED AMENDMENT

Wherein deleted material is shown in **[bracketed]** format and amended/additional material is shown in **underlined** format as follows:

IN THE SPECIFICATION

Please substitute the following amended paragraph(s) and/or section(s):

Page 2, Paragraph 3, after line 15, please insert the following:

SUMMARY OF THE INVENTION

An object of the present invention is to provide a three-phase hybrid type stepping motor invention comprises a stator, and a rotor arranged concentrically with the stator and with an air gap therebetween, said stator having an annular stator yoke, six stator poles extending radially and formed at a regular pitch on the inner peripheral surface of the annular stator yoke, and stator windings of three-phase each wound around each stator pole, each of said stator poles having a plurality of small stator teeth at the tip end thereof, said rotor having two splitted rotor elements and a permanent magnet held therebetween and magnetized so as to form N and S poles in the axial direction thereof, and a plurality of small rotor teeth formed at a regular pitch on the outer peripheral surface of each of said rotor elements, said two splitted rotor elements being shifted from each other in angular position by a ½ pitch of the small rotor teeth. A permeance distribution of the small stator teeth is a vernier pitch balanced by a six order harmonic wave, and a tooth width ratio of the small rotor teeth with the small stator teeth is set to 0.35 - 0.45.

Another object of the present invention is to provide a three-phase hybrid type stepping motor wherein a permeance distribution of the small stator teeth is a vernier pitch balanced by a

three order harmonic wave, and a tooth width ratio of the small rotor teeth with the small stator teeth is set to 0.35 – 0.45.

A further object of the present invention is to provide a three-phase hybrid type stepping motor, wherein a number of the small rotor teeth is fifty, a number of the small stator teeth is eight, a tooth pitch is 7.05, and a tooth width ratio of the small rotor teeth with the small stator teeth is set to **[0.36 – 0.44]** **0.35 – 0.45**.

A still further object of the present invention is to provide a three-phase hybrid type stepping motor, wherein the three-phase windings of the stator are connected in the form of delta.

These and other objects and features of the present invention will become apparent from the following description is conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a vertically sectional front view of a conventional three-phase hybrid type stepping motor with twelve poles having windings;

FIG. 1B is a vertically sectional left side (N pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 1A;

FIG. 1C is a vertically sectional right side (S pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 1A;

FIG. 2A is a vertically sectional front view of a conventional three-phase hybrid type stepping motor with six poles having windings;

FIG. 2B is a vertically sectional left side (N pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 2A;

FIG. 2C is a vertically sectional right side (S pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 2A;

FIG. 3 is an explanation view of a stator core of a three-phase hybrid type stepping motor with six poles having windings and a stator core of a three-phase hybrid type stepping motor with twelve poles having windings;

FIG. 4A is an explanation view of a wiring system of a three-phase hybrid type stepping motor with six poles having windings;

FIG. 4B is an explanation view of a wiring system of a three-phase hybrid type stepping motor with six poles having windings;

FIG. 5 is a diagram showing characteristic features of the cogging torque, magnetic flux, and distortion rate of the magnetic flux wave form of the three-phase hybrid type stepping motor with six poles having windings; and

FIG. 6 is a diagram showing characteristic features of the cogging torque, mantic flux, and distortion rate of the magnetic flux wave form of the three-phase hybrid type stepping motor with six poles having windings.

<u>On Page 3, paragraph 3, lines 23-25</u>:

Here, n_1 denotes a total number of **[windings]** <u>**winding turns**</u> of one phase, Φ denotes a magnetic flux of the magnet passing through one turn of windings, ω denotes an angular velocity of the rotor, and $\theta = \omega t$.

On Page 4, paragraph 3, lines 12-19:

According to the Formula 3, it is noted that the induced voltage is in proportion to the number of n_1 of **[windings]** **winding turns**, the number p of rotor teeth, the angular velocity ω, and the magnetic flux Φ, respectively. On the other hand, an electrical input is $e_1 \times i_1$ when a current is passed through a winding which generates the induced voltage e_1. The electrical in put is equal to a mechanical output (torque $\tau_1 \times$ angular velocity ω of rotor) of one phase as expressed by Formula 4.

On Page 6, Equation 8, lines 21-24:

L_1 = *number of series windings of one phase* / *number of parallel windings of one phase* x

(number of ***[windings]*** **winding turns** *of one pole)*^{2} x

$$\textit{permeance of one pole} = \frac{n_s}{n_p}\left(\frac{n_1}{n_w/m}\right)^2 \frac{P_T}{n_w} \quad \ldots(8)$$

On Page 8, after Table 2, line 20, please insert:

The vernier pitch θ_v can be expressed by Equation 9:

$$\theta v = \frac{360}{p} \pm \frac{360}{pnQ} (\deg rees) \qquad \textbf{.... Equation 9}$$

where p is the pole pair number, such as 50, n is the cancellation order and Q is small tooth number.

<u>On Page 9, paragraph 3, lines 17-25</u>:

In the three-phase motor, the balance harmonic wave for minimizing the cogging torque is six order, but the normal motor is four order, so that it is considered that the balance harmonic wave of three order is effective to reduce the tertiary harmonic wave. Accordingly, the cogging torque, magnetic flux, and rate of distortion of the magnetic flux are calculated with respect to four kinds items including one having no vernier. **[The width of the pole tooth is set to 0.4 which is considered as the best.]** <u>**The ratio of the width of the stator pole tooth to the rotor small tooth pitch is set to .4 which is considered as the best.**</u> It is judged that the six order balance is the best in consideration of each performance totally.

<u>On Page 10, paragraph 1, lines 1-5</u>:

The width of the pole tooth in the optimum six order vernier system is considered. FIG. 6 shows results of the calculation <u>**concerning the small tooth**</u> wherein the tooth width of the rotor is considered as the same as that of the stator in order to simplify the calculation. As shown in FIG. 6, the <u>**ratio of the**</u> small tooth width <u>**to rotor teeth pitch of 0.35 - 0.45 is most preferable and among the above ratios the ratio**</u> of about 0.4 is considered as the best.

<u>On Page 13, paragraph 6, lines 20-25 bridging Page 14, lines 1-12</u>:

A three-phase hybrid type stepping motor according to the present invention comprises a stator 5 and a rotor 9 arranged concentrically with the stator 5 and with an air gap therebetween, said stator 5 having an annular stator yoke 1, a plurality of stator poles 2 extending radially and formed at a regular pitch on the inner peripheral surface of the annular stator yoke 1, a plurality of stator poles 2 extending radially and formed at a regular pitch on the inner peripheral surface of the annular stator yoke 1, stator windings 3 of three-phase each wound around each stator pole 2, each of said stator poles 2 having six small stator teeth 4 at the tip end thereof, said rotor 9 having two splitted rotor elements 7 and a permanent magnet 8 held therebetween and

magnetized so as to form N and S poles in the axial direction thereof, and fifty small rotor teeth 6 formed at a regular pitch on the outer peripheral surface of each of said rotor elements 7, said two splitted rotor elements 9 being shifted from each other in angular position by ½ pitch of the small rotor teeth 6. A permeance distribution of the six small stator teeth 4 is a vernier pitch balanced by six order harmonic wave, and a **ratio of the** tooth width **[ratio]** of the small **[rotor]** **stator** teeth **[6]** 4 with the **[small stator teeth 4 is]** **pitch of the small rotor tooth** set to 0.35 – 0.45.

On Page 14, paragraph 1, lines 13-16:

In a further embodiment of the present invention, a permeance distribution of the six small stator teeth 4 is a vernier pitch balanced by three order harmonic wave, and a **ratio of the** tooth width **[ratio]** of the small **[rotor]** **stator** teeth **[6]** 4 with the **[small stator teeth 4]** **pitch of the small rotor tooth** is set to 0.35 - 0.45.

On page 14, paragraph 2, lines 17-20:

In a further embodiment of the present invention, a number of the small stator teeth 4 is eight, a tooth pitch is 7.05, and a **[tooth width]** ratio of the small **[rotor]** **stator** teeth **[6 with]** 4 to the **[small stator teeth 4]** **pitch of the small rotor tooth** is set to **[0.36 – 0.44]** **[0.36 – 0.44]** **0.35 – 0.45**.

IN THE CLAIMS

Please amend Claims 1-4 as follows.

1. (Amended) In a three-phase hybrid type stepping motor comprising a stator, and a rotor arranged concentrically with the stator and with an air gap therebetween, said stator having an annular stator yoke, six stator poles extending radially and formed at a regular pitch on

the inner peripheral surface of the annular stator yoke, and stator windings of three-phase each wound around each stator pole, each of said stator poles having a plurality of small stator teeth at the tip end thereof, said rotor having two splitted rotor elements and a permanent magnet held therebetween and magnetized so as to form N and S poles in the axial direction thereof, and a plurality of small rotor teeth formed at a regular pitch on the outer peripheral surface of each of said rotor elements, said two splitted rotor elements being shifted from each other in angular position by a 1/2 pitch of the small rotor teeth, a permeance distribution of the small stator teeth is a vernier pitch balanced by a six order harmonic wave, and a **ratio of the** tooth width **[ratio]** of the small **[rotor teeth with the small]** stator teeth **to the pitch of the small rotor teeth** is set to .35-.45.

2. (Amended) In a three-phase hybrid type stepping motor comprising a stator, and a rotor arranged concentrically with the stator and with an air gap therebetween, said stator having an annular stator yoke, six stator poles extending radially and formed at a regular pitch on the inner peripheral surface of the annular stator yoke, and stator windings of three-phase each wound around each stator pole, each of said stator poles having a plurality of small stator teeth at the tip end thereof, said rotor having two splitted rotor elements and a permanent magnet held therebetween and magnetized so as to form N and S poles in the axial direction thereof, and a plurality of small rotor teeth formed at a regular pitch on the outer peripheral surface of each of said rotor elements, said two splitted rotor elements being shifted from each other in angular position by a ½ pitch of the small rotor teeth, a permeance distribution of the small stator teeth is a vernier pitch balanced by a three order harmonic wave, and a **ratio of the** tooth width **[ratio]** of the small **[rotor teeth with the small]** stator teeth **to the pitch of the small rotor teeth** is set to 0.35-0.45.